



Genotoxicity and potential carcinogenicity of cyanobacterial toxins - A review

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Abstract:

The occurrence of cyanobacterial blooms has increased significantly in many regions of the world in the last century due to water eutrophication. These blooms are hazardous to humans, animals, and plants due to the production of cyanotoxins, which can be classified in five different groups: hepatotoxins, neurotoxins, cytotoxins, dermatotoxins, and irritant toxins (lipopolysaccharides). There is evidence that certain cyanobacterial toxins are genotoxic and carcinogenic; however, the mechanisms of their potential carcinogenicity are not well understood. The most frequently occurring and widespread cyanotoxins in brackish and freshwater blooms are the cyclic heptapeptides, i.e., microcystins (MCs), and the pentapeptides, i.e., nodularins (NODs). The main mechanism associated with potential carcinogenic activity of MCs and NOD is the inhibition of protein phosphatases, which leads to the hyperphosphorylation of cellular proteins, which is considered to be associated with their tumor-promoting activity. Apart from this, MCs and NOD induce increased formation of reactive oxygen species and, consequently, oxidative DNA damage. There is also evidence that MCs and NOD induce micronuclei, and NOD was shown to have aneugenic activity. Both cyanotoxins interfere with DNA damage repair pathways, which, along with DNA damage, is an important factor involved in the carcinogenicity of these agents. Furthermore, these toxins increase the expression of TNF- α and early-response genes, including proto-oncogenes, genes involved in the response to DNA damage, cell cycle arrest, and apoptosis. Rodent studies indicate that MCs and NOD are tumor promoters, whereas NOD is thought to have also tumor-initiating activity. Another cyanobacterial toxin, cylindrospermopsin (CYN), which has been neglected for a long time, is lately being increasingly found in the freshwater environment. The principal mechanism of its toxicity is the irreversible inhibition of protein synthesis. It is pro-genotoxic, and metabolic activation by cytochrome P-450 enzymes is needed for its genotoxic activity. In metabolically competent cells, it induces DNA strand breaks and exerts clastogenic and aneugenic activity. In addition, CYN increased the expression of p53 regulated genes involved in cell cycle arrest, DNA damage repair, and apoptosis. It also has cell transforming potential, and limited preliminary rodent studies indicate that CYN could have tumor-initiating activity. In 2010, the International Agency for Research on Cancer (IARC) classified MCLR as possible human carcinogen (Group 2B). Although there is not enough available information for the classification of other cyanobacterial toxins, the existing data from in vitro and in vivo studies indicate that NOD and especially CYN may be even more hazardous than MCLR to human and animal health. In addition in the environment, cyanobacterial toxins occur in complex mixtures as well as together with other anthropogenic contaminants, and numerous studies showed that the toxic/genotoxic potential of the extracts from cyanobacterial scums is higher than that of purified toxins. This means that the mixtures of toxins to which humans are exposed may pose higher health risks than estimated from the toxicological data of a single toxin. Future research efforts should focus on the elucidation of the carcinogenic potential of NOD, CYN, and the mixture of cyanobacterial extracts, as well as on the identification of possible novel toxins.

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Resource Description

Exposure :

weather or climate related pathway by which climate change affects health

Food/Water Quality

Food/Water Quality: Biotoxin/Algal Bloom

Geographic Feature:

resource focuses on specific type of geography

Freshwater, Ocean/Coastal

Geographic Location:

resource focuses on specific location

Global or Unspecified

Health Impact:

specification of health effect or disease related to climate change exposure

Cancer, Infectious Disease

Infectious Disease: Foodborne/Waterborne Disease

Foodborne/Waterborne Disease: Marine Toxin Syndrome

Resource Type:

format or standard characteristic of resource

Review

Timescale:

time period studied

Time Scale Unspecified